

Epithermal Gold in the Great Basin

Abstract

This paper briefly addresses some aspects of epithermal gold in the Great Basin, including deposition processes, resulting products, the mining processes historical and modern used to retrieve it, and the environmental impacts of such mining. This paper will describe the formation and character of disseminated gold deposits of the Great Basin, especially those located in the Eastern Sierra Nevada. Most people associate California gold with the placers, or nuggets, that sparked the gold rush of 1849, but this paper will not cover that gold rush or the social impact of the gold.

Introduction

Gold causes wars, builds fortunes and edifices, and although the gold standard is no longer in use in the United States, influences world markets. Most of all, gold provokes passionate actions from those involved in its production and sale. Mining operations take up vast tracts of land and significantly impact the environment. It is used as jewelry, money and in industrial processes. All these effects of a shiny, yellow metal, Au, make it worth of study.

General types of gold deposits

Like any precious material, gold is not distributed evenly, or even close to evenly, around the world. Concentrations of deposits are found in six continents: Africa, Asia, Australia, Europe, and North and South America (Boyle 2). Areas particularly known

for gold include India, China, Russia, West Africa and western North America (Boyle 5-6). Gold appears in several distinct forms. Placers are loose nuggets of the metal, often found in streams running toward the ocean and the gold is deposited on the inside of bends in the stream. These prompted the boom in California west of the Sierra Nevada (Boyle). Gold is also deposited in veins and skarns, and throughout many types of rock: metamorphic, volcanic, and sedimentary.

Macro-scale relationship to tectonic and volcanic activity

Epithermal gold systems in general are associated with convergent plate boundaries, like in the Andes of South America (Australian). The geology of the Great Basin, with active tectonics and volcanic activity, makes it a prime location for gold to be deposited epithermally. While on the field excursions, students in G188, including the author, observed the results of a volcanic system that created the Long Valley Caldera. There is a great deal of magma to drive the hydrothermal processes and a pervasive system of fractures due to earthquakes that make room for the deposits, products of the hydrothermal process.

The Products of Epithermal Gold Systems

General classification and characteristics of epithermal gold systems

There are four types of gold deposits from the subvolcanic suite, or near-surface, according to the Schneiderhohn classification system: Epithermal propylitic gold-quartz veins and silver-gold veins; epithermal gold-telluride veins; epithermal gold-selenium veins; and alunitic gold deposits. Epithermal deposits of gold occur in veins within

rhyolite country rock (Hydrothermal). The categorization of ore deposits as epithermal, mesothermal or hypothermal is fairly arbitrary in terms of choosing specific depth and temperature boundaries (Park 215). The Australian Museum places epithermal gold deposits within a vertical distance of surface (0) to 350 meters, and the boiling temperatures of the loaded water between 230 and 260 degrees Celsius. The overall deposits are not usually large in total volume of gold, but the ore is densely disseminated, so the deposit is richer.

Alteration products that indicate gold deposits

Deposits include silver mixed with gold, and as the author heard in Bodie, this combination is worthless until the two metals are separated (Hydrothermal). Other products of a hydrothermal system indicate that gold might be near by. “Pathfinders” are minerals that are associated with gold deposits and which occur in higher concentrations, making it easier to find them than to find gold (Hydrothermal). The pathfinders can be used to make prospecting by mining companies more efficient and less expensive.

Mineral salts on an outcrop of rock serve as an indicator of ore deposits (Young 20).

Associated with gold is hematite’s reddish brown, an iron oxide that is created from the weathering of iron pyrite (Young 20). Yellow limonite is another indicator of a possible gold deposit (Young 236). Clays and material such as kaolinite, like that in the kaolin mine that the G188 class and author visited, also are “alteration products” of a hydrothermal system (Park 147).

The use of such products other than gold to find rich deposits of gold is less easy if there have been more than one cycle of hydrothermal deposits because the subsequent deposits alter the alterations from the previous deposits (Park 147). Unlike sedimentary

rock that has distinct layers, such as that from an ancient lakebed, there is no clear chronology to follow to the gold. In the Great Basin, chemical analysis must be used sometimes to find very disseminated gold deposits with tiny grains, like the deposit in Carlin, Nevada, where the gold was invisible without laboratory techniques (Park 152).

Other valuable products of epithermal gold systems

Epithermal gold ore deposits do not just have alterations that are valuable as markers, but also have other minerals that may be valuable such as native silver, electrum, acanthite, tetrahedrite, silica in the form of quartz, and semiprecious gems like amethyst and opal (Australian).

The Processes of Epithermal Gold Systems

Misunderstandings of the processes that deposit gold plagued the early miners (Young 8). Because the field work at the time was of low quality with such poor observations that marble and quartz were mixed up, the products were misinterpreted (Young 16). Prospectors believed that they would find more gold as they dug deeper (Young 9). The results, of course, of such a major misconception were lost money, careers wasted and land reshaped by hopeless mining (Young).

Essential components of a hydrothermal system for gold

Gold is very insoluble and unreactive (Hydrothermal). These properties mean that to be moved, gold must be carried by something, and that something is water. Epithermal gold systems are hosted by volcanic areas and the deposits are relatively young, the oldest being from the Mesozoic time (Australian). The epithermal gold deposits can come

directly from loaded magma or loaded, heated water. Gold was even recovered from the ash of the Mt. Vesuvius eruption to produce jewelry (Volcano).

Heating from magma makes gold more soluble beneath the surface that allows it to be carried up to form epithermal, or shallow hydrothermal, deposits (Hydrothermal). Then the gold must be deposited somehow within the country rock. The country rock riddled with fractures, like that in the Great Basin, allows gold-laden water to permeate thoroughly (Press 529). In some cases, the pressure from the hydrothermal fluids causes fractures (Australian). The pregnant water cools rapidly as it gets closer to the surface, and cooling is one method to make gold precipitate out from solution (Hydrothermal). Another method is to depressurize the solution, which also occurs naturally as the water gets closer to the surface and has less and less rock pressing down on it. Another method that precipitates the gold is changing the chemical solution by adding new minerals (Hydrothermal). This occurs naturally when the solution rises past a mineral rich rock, specifically pyrite (Hydrothermal). This process requires many cycles to achieve a deposit, since only a small amount of gold is deposited at one time (Hydrothermal).

Since the gold is not released from solution until the hydrothermal fluid is near the surface, epithermal gold deposits produce wide swaths of ore that may be tens of meters long, but only a few hundred meters deep (Australian). The process of multiple boilings creates the extensive lateral deposit that is not deep (Volcano).

A sketch of an epithermal gold depositing system:

Note that the water cycles, so the same water molecules may carry many loads of gold. The water cycle is similar to that described to the G188 class at the hydrothermal plant. Note also that there are groups of minerals deposited at different temperatures, or different depths. The gas rising out of the hot springs is hydrogen sulfide, which probably accounts for the sulphurous smell observed when the G188 class visited hot springs.

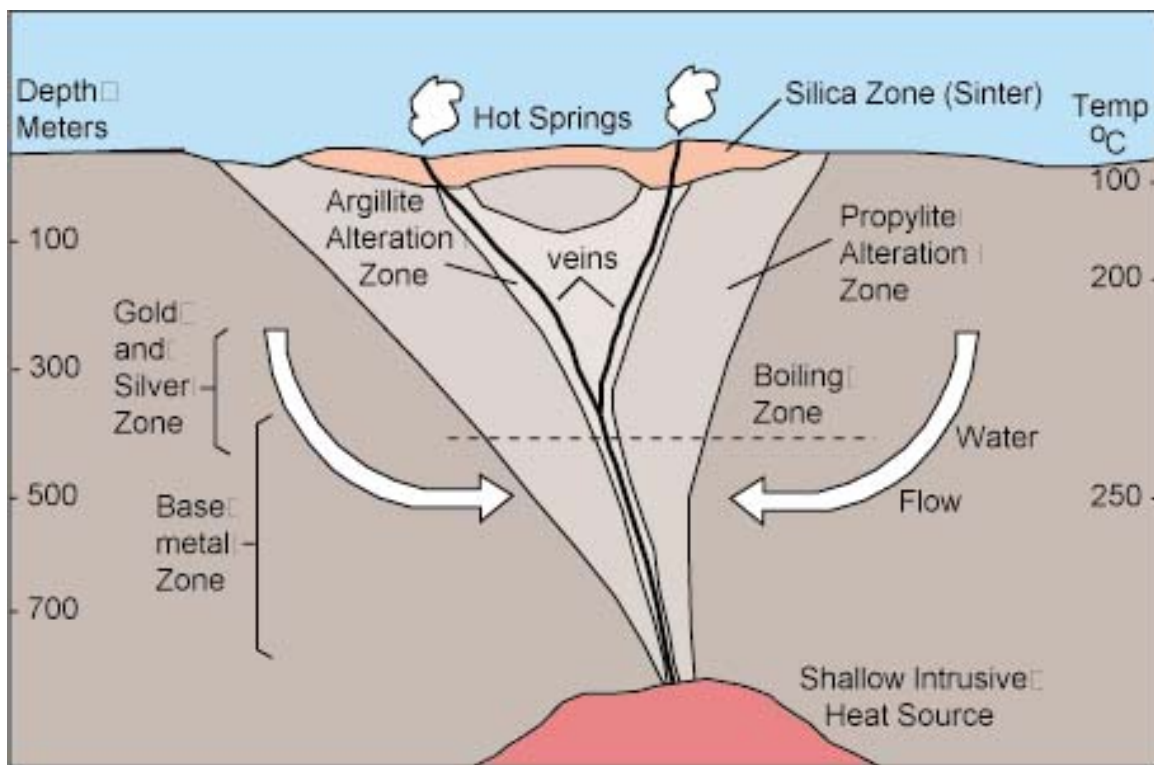
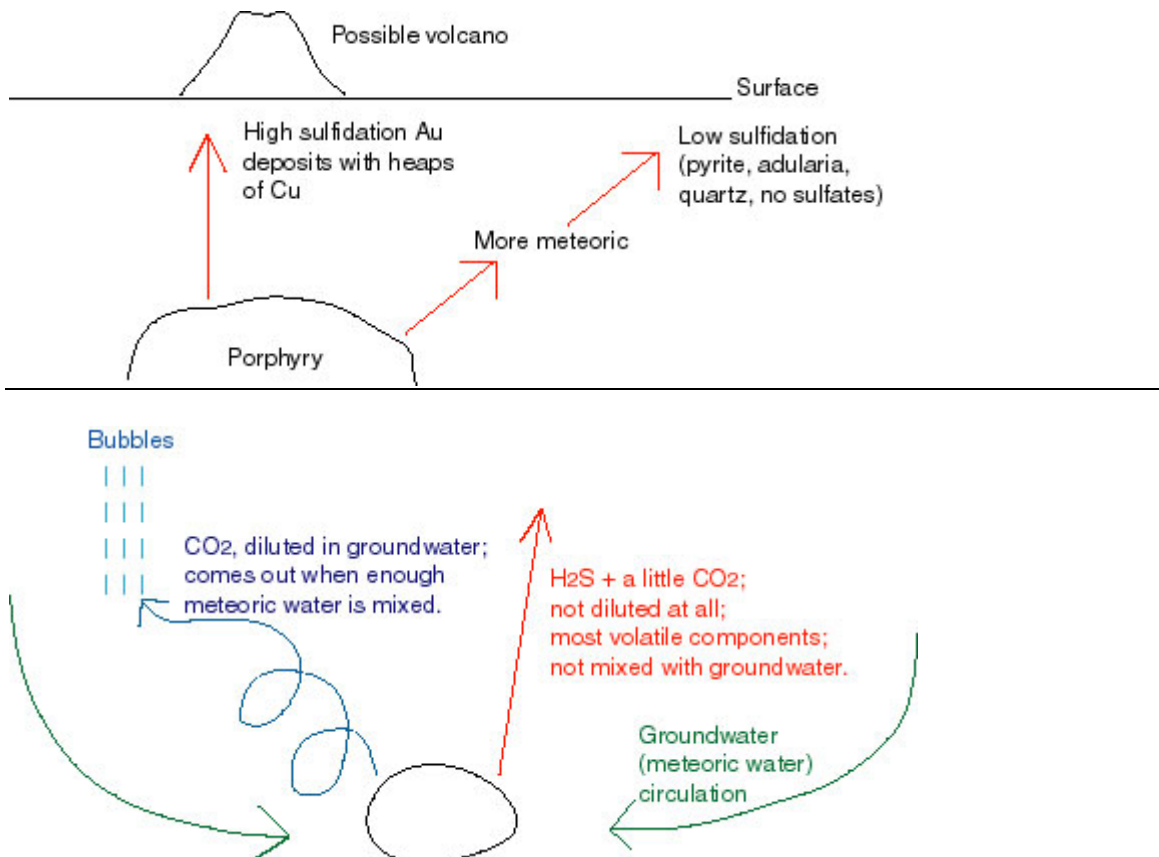


Figure from "Volcano"/ University of North Dakota (ITAM Gold by the Minerals Council of Australia.) <http://volcano.und.nodak.edu/vwdocs/minerals/gold.html>

Two different chemical outcomes



Figures above from Australian National University (see "Australian" in references).

Discussion on Economics and the Environment

In some of the literature, there is an assumption that mining gold is a battle, suggesting an inherent conflict between the miners and the source (the earth). "Gold is won" is a prime example (Boyle 12). In mining towns such as Bodie in the 1870s and 1880s, mining was a dangerous, laborious process. The ore was hammered beneath the stamps pictured below, and then filtered with water to separate the gold and silver from the rock.



Mill interior with stamps at Bodie, Ca. Photo courtesy of Jerry Robison.

Today mining in the Great Basin is still dangerous, but the techniques are different. In Nevada gold is the most economically significant mineral resource: in 2004, the state produced \$3.5 billion in minerals, and all but \$600 million was from gold (Nevada 6). The state is very productive, with a metric ton of gold per square kilometer ratio of 745, while the world average is only 16 (Nevada 7). Production of gold logically is related to the market price, and in the graph below from the Nevada study gold production is inversely related to the price of gold (the price line and the bars are a rough mirror image: when one goes up, the other goes down).

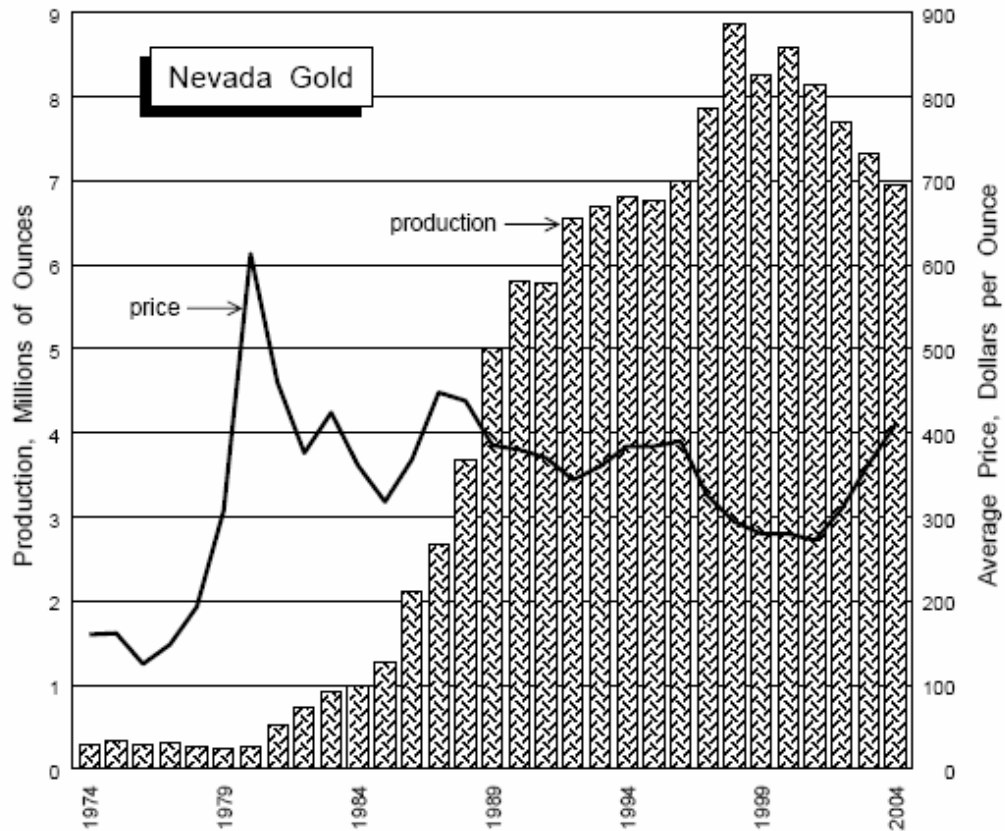


Figure from "The Nevada Mineral Industry 2004."

Nevada mining (and presumably that in California parts of the Great Basin as well) has a significant future, assuming gold prices remain as high as they are now: there are 15-20 more years of mining at sustained levels from the reserves (Nevada 11). If prices fell significantly, of course, it might no longer be efficient to mine.

Environmental Impacts of Modern Gold Mining

Another threat to the immediate efficiency of Nevada gold mining (maximum yield right now at the lowest cost, versus long term environmental costs, that may not be realized, or absorbed, by the companies, but rather by the public) are issues of environmental concern including land deformation from mines and chemical waste from

the milling. Specifically, mercury is still used (it was also used in the Bodie era), and proper disposal is a challenge with this element that is extremely harmful to human development, especially in children (Nevada 12). Also, the leaching process to separate gold from ore leaves huge piles of rock, soaked in chemicals that require "closure" (Nevada 12). Cyanide is a particular concern but mine operators degrade it with sunlight and artificial techniques (Gold). Dewatering and the chemically loaded water used in mining present another environmental challenge. In California land deformation was addressed by a 1977 law, the Surface Mining Control and Reclamation Act, that mandates mine owners plan and execute a strategy to return the land to its original shape (Gold Mining). As would be expected, two extreme "end member" sides emerge from Internet searches: industrialists who find regulation generally burdensome, and environmental activists who find industrial activity generally appalling. The author chose to refer to the government agency on this, realizing that the state government has a huge incentive in the form of tax revenue to promote a major, \$3.6 billion industry. However, a mitigating factor in the report's credibility is the involvement of an education institution and its calm, informative tone.

Conclusion

Epithermal gold will continue to be a significant source of the world's gold supply for jewelry, commodities, electronics and industry. Prospecting and mining technology should continue to improve, which will open up more deposits of economic value. People in gold mining areas ought to be aware that as mining improves efficiency, wider swaths

of land can be mined, so a widening environmental impact is of concern to human health, water supplies, agriculture, wildlife and their habitats and aesthetic preservation.

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